Cross section set and transport properties of Ne\(^+\) in CF\(_4\)

To cite this article: Z Raspopovi et al 2015 J. Phys.: Conf. Ser. 635 022099

View the article online for updates and enhancements.
Cross section set and transport properties of Ne$^+$ in CF$_4$

Z. Raspopović*, Ž. Nikitović*, S. Tošić and V. Stojanović **

*Institute of Physics Belgrade, University of Belgrade, P.O. Box 57, 11000 Zemun Serbia

Synopsis
Cross section set for scattering Ne$^+$ ions in CF$_4$ is assessed by using available experimental data for charge transfer cross sections. Monte Carlo method is used to calculate transport properties of Ne$^+$ ions in CF$_4$.

Charge transfer reactions of ions with molecules are unavoidable elementary processes in modeling kinetics in terrestrial, industrial, and astrophysical plasmas. In selected cases charge transfer reactions are known to represent the most significant part of a cross section set. Line spectra of excited atoms obtained in spectrometric measurements in CF$_4$ indicate that the charge transfer reaction is dominant process in collisions with inert gas ions. Thus, in this work we assessed cross section set for Ne$^+$ in CF$_4$ by using existing experimental data [1] for charge transfer collisions producing radical ions of CF$_4$.

Since no direct information is found in the literature how mobility of high recombination energy ions such as Ne$^+$ ions behaves in CF$_4$ we also calculated transport parameters by using Monte Carlo simulation technique [2].

The cross sections presented by Fisher et al [1] were used to determine the elastic momentum transfer cross section (“elastic” in Fig. 1) assuming the total momentum transfer cross section $\sigma_{tot}$ is known. At low energies we assumed that $\sigma_{tot}$ is Langevin’s cross section and elastic momentum transfer cross section is determined by deducing all reactive cross sections.

Average polarizability of CF$_4$ is not well established [1] and may produce discrepancy for calculated mobility of ions in CF$_4$ [3] and thus affect plasma parameters prediction in modeling. We adopted value of 3.86 Å$^3$ used by Stojanović et al [3] who found excellent agreement between experimental and calculated mobility of CF$_3^+$ ions in CF$_4$.

Further, extrapolation of elastic momentum transfer cross section trend beyond crossing point of Langevin’s and hard sphere (HS) cross section [1] is done by smoothly connecting to $1/v^2$ trend [4] where $v$ is the center-of-mass velocity (see Fig. 1).

At all ion kinetic energies above 50 eV reactive cross sections are extrapolated by constant values. Effect of various extrapolations (short dot-dashed or dashed line in Fig. 1) of unusual behavior at low energy, observed with measurements of the cross section leading to formation of CF$_3^+$ (where irrespective of the Ne$^+$ spin state exothermic behavior of reaction is expected) is found negligible on mobility. Reduced mobility for Ne$^+$ ions as a function of $E/N$ (E-electric field, N-gas density) compared with Langevin’s value is shown in Fig. 2.

Figure 1. Cross section set for Ne$^+$ + CF$_4$.

Figure 2. Reduced mobility for Ne$^+$ in CF$_4$ at 300 K.

References

*E-mail: stoyanov@ipb.ac.rs